

WHAT IS CLAIMED IS:

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1. A cleaning unit for removing toner remaining on a surface of an image carrier of an image-forming apparatus, comprising:

10 a vibration member extending in a direction of a width of the image carrier, the vibration member having at least one vibration application part attached thereto;

15 a blade member attached to at least an end region of the vibration member, the blade member extending in the direction of the width of the image carrier; and

20 a driving part configured to drive the at least one vibration application part at a driving frequency, the driving frequency being a resonance frequency,

wherein the vibration member is configured to provide vibration to the blade member and a force to press the blade member against the image carrier.

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2. The cleaning unit as claimed in claim 1,  
wherein the driving part is configured to be capable  
of changing the driving frequency.

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3. The cleaning unit as claimed in claim 2,  
wherein the driving frequency of the driving part is  
10 set based on frictional resistance between the blade  
member and the image carrier.

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4. The cleaning unit as claimed in claim 3,  
wherein the driving frequency of the driving part is  
set based on a coefficient of friction of the surface  
of the image carrier.

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5. The cleaning unit as claimed in claim 3,  
25 wherein the driving frequency of the driving part is

set based on rotational torque of the image carrier.

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6. The cleaning unit as claimed in claim 3,  
wherein the driving frequency of the driving part is  
set based on a result of detection of a cleaning  
characteristic.

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7. The cleaning unit as claimed in claim 1,  
15 wherein the at least one vibration application part  
includes a piezoelectric element.

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8. The cleaning unit as claimed in claim 1,  
wherein the toner is polymerized toner formed by  
polymerization.

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9. The cleaning unit as claimed in claim 1, wherein the resonance frequency is determined by the blade member and the image carrier.

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10. A process cartridge freely attachable to and detachable from a main body of an image forming apparatus, comprising:

at least one of an image carrier, a charging unit, a development unit, and a transfer unit; and

a cleaning unit configured to remove toner remaining on a surface of the image carrier,

15 the cleaning unit including:

a vibration member extending in a direction of a width of the image carrier, the vibration member having at least one vibration application part attached thereto;

20 a blade member attached to at least an end region of the vibration member, the blade member extending in the direction of the width of the image carrier; and

a driving part configured to drive the  
25 at least one vibration application part at a driving

frequency, the driving frequency being a resonance frequency,

wherein the vibration member is configured to provide vibration to the blade member and a force  
5 to press the blade member against the image carrier.

10 11. An image-forming apparatus forming an image by electrophotography, comprising:

a cleaning unit configured to remove toner remaining on a surface of an image carrier of the image-forming apparatus,

15 the cleaning unit including:

a vibration member extending in a direction of a width of the image carrier, the vibration member having at least one vibration application part attached thereto;

20 a blade member attached to at least an end region of the vibration member, the blade member extending in the direction of the width of the image carrier; and

a driving part configured to drive the  
25 at least one vibration application part at a driving

frequency, the driving frequency being a resonance frequency,

wherein the vibration member is configured to provide vibration to the blade member and a force  
5 to press the blade member against the image carrier.

10 12. An image-forming apparatus forming a color image, comprising:

a plurality of process cartridges freely attachable to and detachable from a main body of the image forming apparatus,

15 the process cartridges each including:

at least one of an image carrier, a charging unit, a development unit, and a transfer unit; and

a cleaning unit configured to remove  
20 toner remaining on a surface of the image carrier,

the cleaning unit including:

a vibration member extending in a direction of a width of the image carrier, the vibration member having at least one vibration  
25 application part attached thereto;

a blade member attached to at least an end region of the vibration member, the blade member extending in the direction of the width of the image carrier; and

5 a driving part configured to drive the at least one vibration application part at a driving frequency, the driving frequency being a resonance frequency,

wherein the vibration member is configured  
10 to provide vibration to the blade member and a force to press the blade member against the image carrier.

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13. A cleaning unit, comprising:

a cleaning blade configured to come into contact with an image carrier and remove toner remaining thereon,

20 the cleaning blade including:

a vibration application member;

a vibration member to which the vibration application member is attached; and

an elastic blade member attached to the  
25 vibration member,

wherein: the vibration member has first and second ends, the first end being fixed to a fixing member and the second end being directed to the image carrier so that an end of the blade member attached  
5 to the vibration member comes into contact with the image carrier; and

the vibration application member expands and contracts in in-plane directions thereof to generate flexural vibration in the vibration member, the  
10 vibration application member being driven to expand and contract in the in-plane directions in a same phase.

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14. The cleaning unit as claimed in claim 13, wherein maximum amplitude of a mode of vibration caused in an end part of the blade member in an  
20 extending direction thereof by a frequency of voltage applied to the vibration application member is smaller than an average particle size of the toner.

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15. The cleaning unit as claimed in claim  
14, wherein the voltage applied to the vibration  
application member to vibrate the vibration  
application member is set so that the amplitude of  
5 vibration of the end part of the blade member is  
constant.

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16. The cleaning unit as claimed in claim  
13, wherein maximum amplitude of vibration of the  
image carrier in a part thereof contacting an end  
part of the blade member is smaller than an average  
15 particle size of the toner, the maximum amplitude  
being caused by vibration of the blade member.

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17. The cleaning unit as claimed in claim  
16, wherein the voltage applied to the vibration  
application member to vibrate the vibration  
application member is set so that the amplitude of  
25 vibration of the end part of the blade member is

constant.

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18. The cleaning unit as claimed in claim  
13, wherein a driving frequency  $f_p$  applied to the  
vibration application member is above an audible  
range, and satisfies a condition  $f_p > \sqrt{2} \times f_n$ , where  $f_n$   
10 is a resonance frequency of a mode of vibration  
having a node in an end part of the blade member.

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19. The cleaning unit as claimed in claim  
13, wherein the vibration application member  
comprises a plurality of piezoelectric elements.

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20. A cleaning unit, comprising:  
a cleaning blade configured to come into  
25 contact with an image carrier and remove toner

remaining thereon,

the cleaning blade including:

a multilayer vibration application  
member;

5 a vibration member to which the  
vibration application member is attached; and

an elastic blade member attached to the  
vibration member,

wherein the multilayer vibration application  
10 member is disposed between the vibration member and a  
fixing member disposed opposite the vibration member  
so as to couple the vibration member and the fixing  
member and cause an end of the blade member attached  
to the vibration member to come into contact with the  
15 image carrier, the multilayer vibration application  
member being driven to expand and contract in a same  
phase between the fixing member and the vibration  
member.

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21. The cleaning unit as claimed in claim  
20, wherein maximum amplitude of a mode of vibration  
25 caused in an end part of the blade member in an

extending direction thereof by a frequency of voltage applied to the multilayer vibration application member is smaller than an average particle size of the toner.

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22. The cleaning unit as claimed in claim 10 21, wherein the voltage applied to the multilayer vibration application member to vibrate the multilayer vibration application member is set so that the amplitude of vibration of the end part of the blade member is constant.

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23. The cleaning unit as claimed in claim 20 20, wherein maximum amplitude of vibration of the image carrier in a part thereof contacting an end part of the blade member is smaller than an average particle size of the toner, the maximum amplitude being caused by vibration of the blade member.

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24. The cleaning unit as claimed in claim  
23, wherein the voltage applied to the multilayer  
vibration application member to vibrate the  
multilayer vibration application member is set so  
5 that the amplitude of vibration of the end part of  
the blade member is constant.

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25. The cleaning unit as claimed in claim  
20, wherein a driving frequency  $f_p$  applied to the  
multilayer vibration application member is above an  
audible range, and satisfies a condition  $f_p > \sqrt{2} \times f_n$ ,  
15 where  $f_n$  is a resonance frequency of a mode of  
vibration having a node in an end part of the blade  
member.

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26. The cleaning unit as claimed in claim  
20, wherein the multilayer vibration application  
member comprises a plurality of multilayer  
25 piezoelectric elements.

27. A cleaning unit, comprising:

a cleaning blade configured to come into contact with an image carrier and remove toner remaining thereon,

5 the cleaning blade including:

a vibration application member;

a vibration member to which the vibration application member is attached; and

10 an elastic blade member attached to the vibration member,

wherein: the vibration member has a fixed first end and a second end directed to the image carrier so that an end of the blade member attached to the vibration member comes into contact with the  
15 image carrier;

the vibration application member expands and contracts in in-plane directions thereof at a frequency in a frequency band above an audible range so as to cause flexural vibration in the vibration  
20 member; and

a gap formed between the image carrier and the blade member by propagation of vibration generated by a drive member rotating the image carrier is smaller than an average particle size of  
25 the toner.

28. The cleaning unit as claimed in claim  
27, wherein a frequency of the vibration generated by  
the drive member is excluded from a frequency band  
where a mode of vibration occurs in an end part of  
5 the blade member.

10 29. The cleaning unit as claimed in claim  
28, wherein the drive member is a stepper motor; and  
a frequency of driving pulses driving the  
stepper motor is excluded from a frequency band where  
a mode of vibration occurs in an end part of the  
15 blade member.

20 30. The cleaning unit as claimed in claim  
28, wherein the drive member is a motor whose number  
of poles and number of phases are s and m,  
respectively; and

a frequency determined by (s × m) is  
25 excluded from a frequency band where a mode of

vibration occurs in an end part of the blade member.

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31. The cleaning unit as claimed in claim 28, wherein a drive transmission mechanism of the drive member is a gear whose number of rotations and number of teeth are  $\underline{r}$  and  $\underline{z}$ , respectively; and

10 a meshing frequency of the gear determined by  $(\underline{z} \times \underline{r})$  is excluded from a frequency band where a mode of vibration occurs in an end part of the blade member.

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32. The cleaning unit as claimed in claim 28, wherein a drive transmission mechanism of the drive member is a gear whose number of rotations and number of teeth are  $\underline{r}$  and  $\underline{z}$ , respectively; and

20 a frequency that is an integral multiple of a meshing frequency of the gear determined by  $(\underline{z} \times \underline{r})$  is excluded from a frequency band where a mode of vibration occurs in an end part of the blade member.

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33. The cleaning unit as claimed in claim 27, wherein the image carrier is charged by a charging roller provided in contact therewith; and

5 a frequency that is an integral multiple of a frequency of voltage applied to the charging roller is excluded from a frequency band where a mode of vibration occurs in an end part of the blade member.

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34. An image-forming apparatus, comprising:  
an image carrier; and

15 a cleaning unit configured to remove toner remaining on the image carrier,  
the cleaning unit including:

a cleaning blade configured to come into contact with the image carrier and remove the toner remaining thereon,

20 the cleaning blade including:

a vibration application member;

a vibration member to which the vibration application member is attached; and

25 an elastic blade member attached to the vibration member,

wherein: the vibration member has first and second ends, the first end being fixed to a fixing member and the second end being directed to the image carrier so that an end of the blade member attached  
5 to the vibration member comes into contact with the image carrier; and

the vibration application member expands and contracts in in-plane directions thereof to generate flexural vibration in the vibration member, the  
10 vibration application member being driven to expand and contract in the in-plane directions in a same phase.

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35. An image-forming apparatus, comprising:  
an image carrier; and

a cleaning unit configured to remove toner  
20 remaining on the image carrier,

the cleaning unit including:

a cleaning blade configured to come  
into contact with the image carrier and remove the  
toner remaining thereon,

25 the cleaning blade including:

a multilayer vibration application member;

a vibration member to which the vibration application member is attached; and

5 an elastic blade member attached to the vibration member,

wherein the multilayer vibration application member is disposed between the vibration member and a fixing member disposed opposite the vibration member  
10 so as to couple the vibration member and the fixing member and cause an end of the blade member attached to the vibration member to come into contact with the image carrier, the multilayer vibration application member being driven to expand and contract in a same  
15 phase between the fixing member and the vibration member.

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36. An image-forming apparatus, comprising:  
an image carrier; and  
a cleaning unit configured to remove toner  
remaining on the image carrier,  
25 the cleaning unit including:

a cleaning blade configured to come into contact with the image carrier and remove the toner remaining thereon,

the cleaning blade including:

5                   a vibration application member;  
                  a vibration member to which the vibration application member is attached; and  
                  an elastic blade member attached to the vibration member,

10                  wherein: the vibration member has a fixed first end and a second end directed to the image carrier so that an end of the blade member attached to the vibration member comes into contact with the image carrier;

15                  the vibration application member expands and contracts in in-plane directions thereof at a frequency in a frequency band above an audible range so as to cause flexural vibration in the vibration member; and

20                  a gap formed between the image carrier and the blade member by propagation of vibration generated by a drive member rotating the image carrier is smaller than an average particle size of the toner.

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37. A process cartridge, comprising:  
an image carrier;  
a charging unit charging the image carrier;  
a developing unit performing development to  
5 form a toner image on the image carrier;  
a transfer unit transferring the toner image  
to a transfer medium; and  
a cleaning unit configured to remove toner  
remaining on the image carrier,  
10 the cleaning unit including:  
a cleaning blade configured to come  
into contact with the image carrier and remove the  
toner remaining thereon,  
the cleaning blade including:  
15 a vibration application member;  
a vibration member to which the  
vibration application member is attached; and  
an elastic blade member attached  
to the vibration member,  
20 wherein: the vibration member has first and  
second ends, the first end being fixed to a fixing  
member and the second end being directed to the image  
carrier so that an end of the blade member attached  
to the vibration member comes into contact with the  
25 image carrier; and

the vibration application member expands and contracts in in-plane directions thereof to generate flexural vibration in the vibration member, the vibration application member being driven to expand  
5 and contract in the in-plane directions in a same phase.

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38. A process cartridge, comprising:  
an image carrier;  
a charging unit charging the image carrier;  
a developing unit performing development to  
15 form a toner image on the image carrier;  
a transfer unit transferring the toner image to a transfer medium; and  
a cleaning unit configured to remove toner remaining on the image carrier,  
20 the cleaning unit including:  
a cleaning blade configured to come into contact with the image carrier and remove the toner remaining thereon,  
the cleaning blade including:  
25 a multilayer vibration application

member;

a vibration member to which the  
vibration application member is attached; and

an elastic blade member attached  
5 to the vibration member,

wherein the multilayer vibration application  
member is disposed between the vibration member and a  
fixing member disposed opposite the vibration member  
so as to couple the vibration member and the fixing  
10 member and cause an end of the blade member attached  
to the vibration member to come into contact with the  
image carrier, the multilayer vibration application  
member being driven to expand and contract in a same  
phase between the fixing member and the vibration  
15 member.

20 39. A process cartridge, comprising:  
an image carrier;  
a charging unit charging the image carrier;  
a developing unit performing development to  
form a toner image on the image carrier;  
25 a transfer unit transferring the toner image

to a transfer medium; and

a cleaning unit configured to remove toner remaining on the image carrier,

the cleaning unit including:

5 a cleaning blade configured to come into contact with the image carrier and remove the toner remaining thereon,

the cleaning blade including:

a vibration application member;

10 a vibration member to which the vibration application member is attached; and

an elastic blade member attached to the vibration member,

wherein: the vibration member has a fixed  
15 first end and a second end directed to the image carrier so that an end of the blade member attached to the vibration member comes into contact with the image carrier;

the vibration application member expands and  
20 contracts in in-plane directions thereof at a frequency in a frequency band above an audible range so as to cause flexural vibration in the vibration member; and

a gap formed between the image carrier and  
25 the blade member by propagation of vibration



generated by a drive member rotating the image carrier is smaller than an average particle size of the toner.

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40. A color image-forming apparatus,  
comprising:

- 10           at least two process cartridges,  
            the process cartridges each including:  
                an image carrier;  
                a charging unit charging the image  
carrier;  
15           a developing unit performing  
development to form a toner image on the image  
carrier;  
            a transfer unit transferring the toner  
image to a transfer medium; and  
20           a cleaning unit configured to remove  
toner remaining on the image carrier,  
            the cleaning unit including:  
                a cleaning blade configured to  
come into contact with the image carrier and remove  
25   the toner remaining thereon,

the cleaning blade including:

a vibration application  
member;

a vibration member to which  
5 the vibration application member is attached; and

an elastic blade member  
attached to the vibration member,

wherein: the vibration member has first and  
second ends, the first end being fixed to a fixing  
10 member and the second end being directed to the image  
carrier so that an end of the blade member attached  
to the vibration member comes into contact with the  
image carrier; and

the vibration application member expands and  
15 contracts in in-plane directions thereof to generate  
flexural vibration in the vibration member, the  
vibration application member being driven to expand  
and contract in the in-plane directions in a same  
phase.

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41. A color image-forming apparatus,  
25 comprising:

at least two process cartridges,  
the process cartridges each including:  
an image carrier;  
a charging unit charging the image  
5 carrier;  
a developing unit performing  
development to form a toner image on the image  
carrier;  
a transfer unit transferring the toner  
10 image to a transfer medium; and  
a cleaning unit configured to remove  
toner remaining on the image carrier,  
the cleaning unit including:  
a cleaning blade configured to  
15 come into contact with the image carrier and remove  
the toner remaining thereon,  
the cleaning blade including:  
a multilayer vibration  
application member;  
20 a vibration member to which  
the vibration application member is attached; and  
an elastic blade member  
attached to the vibration member,  
wherein the multilayer vibration application  
25 member is disposed between the vibration member and a

fixing member disposed opposite the vibration member  
so as to couple the vibration member and the fixing  
member and cause an end of the blade member attached  
to the vibration member to come into contact with the  
5 image carrier, the multilayer vibration application  
member being driven to expand and contract in a same  
phase between the fixing member and the vibration  
member.

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42. A color image-forming apparatus,  
comprising:

15 at least two process cartridges,  
the process cartridges each including:  
an image carrier;  
a charging unit charging the image  
carrier;  
20 a developing unit performing  
development to form a toner image on the image  
carrier;  
a transfer unit transferring the toner  
image to a transfer medium; and  
25 a cleaning unit configured to remove

toner remaining on the image carrier,

the cleaning unit including:

a cleaning blade configured to  
come into contact with the image carrier and remove  
5 the toner remaining thereon,

the cleaning blade including:

a vibration application  
member;

a vibration member to which  
10 the vibration application member is attached; and  
an elastic blade member  
attached to the vibration member,

wherein: the vibration member has a fixed  
first end and a second end directed to the image  
15 carrier so that an end of the blade member attached  
to the vibration member comes into contact with the  
image carrier;

the vibration application member expands and  
contracts in in-plane directions thereof at a  
20 frequency in a frequency band above an audible range  
so as to cause flexural vibration in the vibration  
member; and

a gap formed between the image carrier and  
the blade member by propagation of vibration  
25 generated by a drive member rotating the image

carrier is smaller than an average particle size of the toner.